Post-larval Food of the Pelagic Coelenterate, *Velella lata*

ROBERT BIERI[1]

HUGE, UNEXPECTED SWARMS of *Velella* that have drifted onto the coasts of France, England, the United States, and other countries have stimulated many of the studies on the "purple sail." Although recent reports (Savilov, 1958; Bieri, 1959) have indicated some of the reasons for the apparently haphazard appearance and disappearance of these swarms, we have little or no idea of the effect of such sporadic invasions on the local fauna. The size of these populations is indicated in several published reports, of which Woltereck's (1904) is typical. This particular swarm when cast onto the beach at Villefranche formed a mound ½ m. wide, ½ m. high, and fully 1000 m. long. Such huge populations must have a considerable effect on the community of organisms in the sea beneath them.

This paper records some quantitative data on the food of *Velella*. Some possible effects of predation by *Velella* on associated zooplankton are suggested.

MATERIAL AND METHODS

In the present study, 137 specimens were used. Ninety-nine of these were obtained by dip-net between 0915 and 1000 at 32° 41′ N., 121° 04′ W. on May 10, 1950. These specimens were sorted into five size-groups and preserved in formalin. On March 29, 1954, 38 specimens were collected in a special surface net between 1400 and 1500 at 32° 40′ N., 118° 16′ W., and were also preserved in formalin.

In the laboratory all gonozooids were cut from the specimens and examined at 12× magnification. Those parts containing visible food were removed and dissected, and the food items were identified. The main central gastrozooids were dissected separately. Details of the weight determinations are given in Bieri and Krinsley (1958).

RESULTS AND DISCUSSION

Only three brief comments on the food of *Velella* appear in the literature. Huxley (1858) found copepod remains in the gonozooids, while Lebour (1947) reported a young "macerated" *Velella* with its "stomach" (main central gastrozooid) full of harpacticoid copepods. Totten (1954) reported a calanoid copepod and crustacean remains in the gonozooids. No quantitative data are available.

In the present study most of the food was found in the gonozooids. Only 33 per cent of the specimens examined had food in the main central gastrozooids. Digestion occurs in both the gonozooids and the gastrozooid, as is evidenced by the exoskeletons of crustaceans found in both places. The food in the gastrozooid was somewhat larger on the average than that in the gonozooids. Possibly the gastrozooid ingests the organisms caught by the gonozooids that are too large for them to ingest. However, the gastrozooid also ingests small items.

In the 99 specimens taken off California in May 1950, fish eggs (mostly those of jack mackerel, *Trachurus symmetricus*[2]) made up 48 per cent of the total food by count. Euphausiid eggs made up 7 per cent of the food items. On the other hand, in 38 specimens taken off California in March 1954, euphausiid eggs made up 78 per cent of the food items and fish eggs 3 per cent by count.

The fish eggs had an average diameter of 1.1 mm., the euphausiid eggs a mean diameter of 0.41 mm. Thus a fish egg has nearly 17 times

[1] Antioch College, Yellow Springs, Ohio. The early stages of this study were carried out at the Scripps Institution of Oceanography, La Jolla, California, and the Lamont Geological Observatory, Palisades, New York. Manuscript received July 29, 1960.

[2] Dr. E. H. Ahlstrom, U. S. Fish and Wildlife Service, La Jolla, Calif., kindly identified the fish eggs.

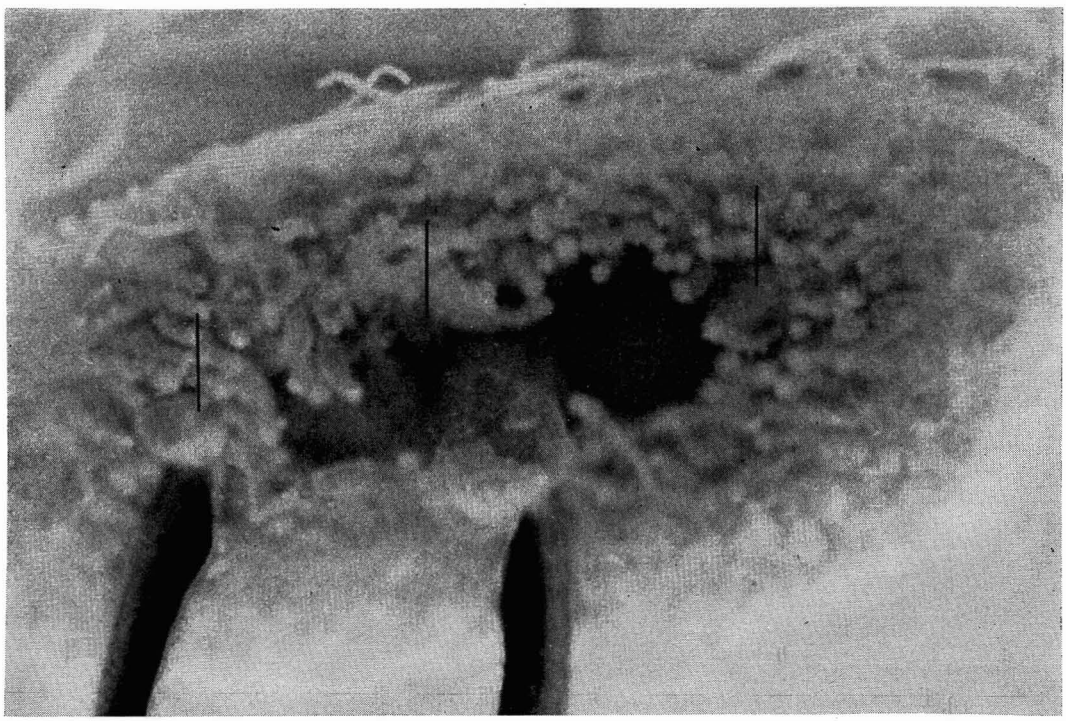

FIG. 1. Ventral side of *Velella* killed and fixed in process of eating three large and three smaller fish eggs. Smaller eggs, marked by vertical lines, have diameter of 1.1 mm. Gastrozooid surrounding central egg has broken and appears as thin film above egg. Darkest egg is not completely ingested.

the volume of a euphausiid egg. This means that in the *Velella* taken in March of 1954, fish eggs almost equalled the volume of euphausiid eggs in the diet of *Velella,* while in the May 1950 sample fish eggs were 120 times the volume of euphausiid eggs. The ventral side of a *Velella* taken in the process of eating six fish eggs is shown in Figure 1.

When the *Velella* were collected in March 1954, a surface net tow was taken at the same time. In Table 1 the per cent composition of the plankton is compared to the per cent composition of the food of *Velella.* Euphausiid metanauplii and copepods were 10 times as common in the plankton as in *Velella* food. On the other hand, euphausiid eggs were nearly 8 times as common in the food of *Velella* as in the surface zooplankton. Larvaceans, which made up 10 per cent of the food by count, formed less than 0.1 per cent of the plankton. If the plankton sample is representative of the food that was available to this particular *Velella* population (change with time or micro-vertical distribution differences may mean the plankton sample is not representative), it appears that motile organisms such as copepods and nauplii are not caught as effectively as are weaker swimming zooplankton, such as the larvaceans or the nonmotile eggs of fish and invertebrates. Nevertheless, comparatively large and active organisms such as larval fish and adult euphausiids are occasionally caught.

In Figure 2 the per cent composition by count of the food of the 99 specimens taken in May 1950 is shown as a function of mean length of *Velella.* Apparently there is no marked food selection by the different sizes of *Velella* although the calanoid copepods (3) increase steadily in importance when *Velella* surpasses a length of 30 mm. This is another indication that motile organisms are not caught as effectively as are nonmotile objects. Besides jack mackerel eggs and the items listed in Table 1, the following items were found in the gono-

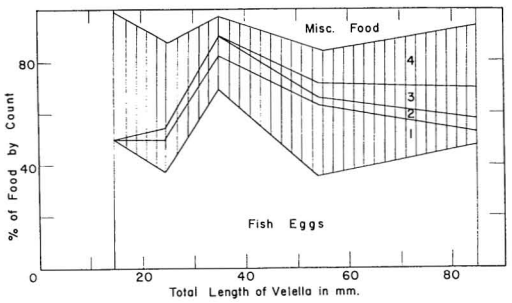

FIG. 2. Per cent composition, by count, of *Velella* food as function of total length of *Velella.* Shaded area is crustacean food. *1,* Euphausiid eggs, *2,* barnacle cyprids, *3,* calanoid copepods, *4,* other crustacean food. There appears to be no marked food selectivity by the different sizes, although copepods increase in importance in diet at sizes above 30 mm.

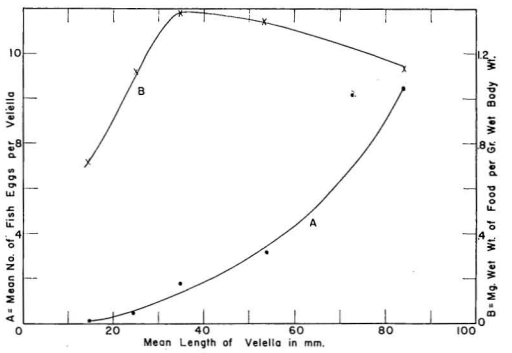

FIG. 3. Amount of food caught as function of length of *Velella.* Although number of fish eggs increases rapidly with length, weight of food caught per gram of wet body weight decreases after length of about 40 mm.

zooids and main central gastrozooids of *Velella* but were not studied quantitatively: larval fish, including a saury; chaetognaths and their eggs; barnacle nauplii, probably of *Lepas;* siphonophores; larvae of decapod Crustacea; adult mysids; copepod eggs and nauplii; larval and adult euphausiids; corycaeid copepods; pteropods. *Velella* also were found to have eaten the diatom *Coscinodiscus* and the medusae of other *Velella.* One specimen had eaten a fish scale. Specimens cast upon the beach were found to have ingested sand into the gastrozooid as well as into the gonozooids. Thus it appears that *Velella* is a carnivore, feeding on anything it can catch, generally weakly swimming or nonmotile zooplankton.

In Figure 3 the mean number of fish eggs caught by various sizes of *Velella* is shown as curve *A.* The number increases rapidly with increasing length of *Velella.*

The amount of food in each size group of *Velella* was too small to allow reliable weight determinations. Therefore, the wet weight of food present was estimated by calculating the volume of the fish eggs, assuming their density to be one, and assuming that the crustacean food on the average was one-third the weight of the fish eggs. On the basis of these assumptions, the weight of food caught per gram wet body weight of *Velella* is shown as a function of the length of *Velella* (Fig. 3, curve *B*). At lengths greater than about 40 mm. the *Velella* increase in weight more rapidly than they increase the amount of food caught.

TABLE 1

FOOD OF *Velella* COMPARED TO ASSOCIATED ZOOPLANKTON

BY COUNT	% OF *Velella* FOOD (38 specimens)	% OF PLANKTON (0–½ m. net tow)
Euphausiid eggs	78	10
Euphausiid metanauplii	0.5	52
Copepods	3	34
Anchovy eggs	3	3
Other fish eggs	0.5	<0.1
Larvacea	11	<0.1
Barnacle cyprids	0.5	<0.1
Hyperiid amphipods	0.5	<0.1
Cladocera (*Evadne*)	1.0	<0.1
Emerita larvae	1.5	<0.1
Parasitic copepods, *Caligus*	0.5	<0.1

CONCLUSIONS

The data given above indicate that *Velella* is essentially carnivorous, feeding more or less indiscriminately on zooplankton primarily within the size range 0.2–10 mm. Motile organisms are not caught as effectively as nonmotile forms. *Velella* may be an important predator on fish eggs, which make up a major part of its diet. Euphausiid eggs are also an important part of its food. Off the California coast the seasonal appearance of *Velella* on the surface is correlated with the spring spawning of pelagic fish, such as hake, saury, sardine, and jack mackerel. The relatively greater abundance of suitable food during the spring months may be one of the factors responsible for the seasonal cycle of reproduction and growth in *Velella.*

REFERENCES

BIERI, R. 1959. Dimorphism and size distribution in *Velella* and *Physalia.* Nat. 184: 1333–1334.

BIERI, R., and D. H. KRINSLEY. 1958. Trace elements in the pelagic coelenterate, *Velella lata.* J. Mar. Res. 16(3): 246–254.

HUXLEY, T. H. 1858. The Oceanic Hydrozoa. Ray Society, London. 141 pp.

LEBOUR, M. V. 1947. An interesting young *Velella* in the Plymouth plankton. J. Mar. Biol. Assoc. 26: 548–550.

SAVILOV, A. I. 1958. Pleuston of the western Pacific. Doklady Akad. Nauk SSSR 122(6): 1014–1017. [In Russian.]

TOTTEN, A. K. 1954. Siphonophora of the Indian Ocean, together with systematic and biological notes on related specimens from other oceans. Discovery Repts. 27: 1–162.

WOLTERECK, R. 1904. Ueber die entwicklung der *Velella* aus einer in der Tiefe vorkommenden Larve. Zool. Jahrb. Supp. VII, Festschrift A. Weismann: 347–372.